Study of cluster surface energies with the three-dimensional Ising model

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It has recently been shown that experimental multifragmentation data contain the signature of a liquid to vapor phase transition manifested by the scaling behavior predicted in the Fisher droplet formalism [1]. The critical exponents τ and σ as well as the critical temperature T_c and the surface energy coefficient c_0 can be directly extracted.

In the droplet formation the surface energy of the fragments plays a crucial role. A deeper understanding of the fragment surface energy for cluster distributions near the phase transition region is important.

The Ising model has been identified as a simple model which describes a liquid to vapor phase transition through Fisher scaling [2]. Within the Ising model [3] we are studying the surface energy of clusters. The validity of the Fisher formalism is examined by extending it in order to take into account the deformation of the clusters. Strongly deformed clusters have a larger surface and thus a larger surface energy and should therefore appear less frequently. Expanding the surface in multipoles, the cluster distribution should depend on the original set of parameters used previously (τ, σ, T_c, etc.) and additionally on the deformation (expansion) parameter.

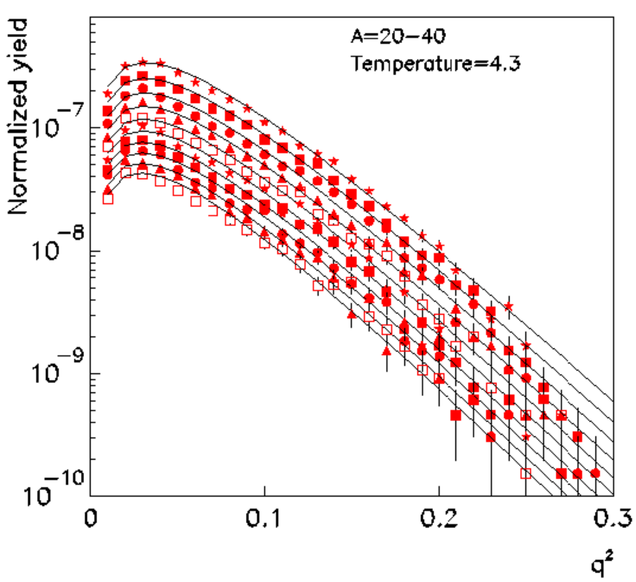

FIG. 1. Quadrupole moment distributions of selected rotationally invariant clusters of size A = 20 (stars), 22 (filled squares), ..., 40 (open squares) generated from 2x10^5 realizations of a cubic lattice of size 32^3 at temperature T = 4.3 J/k_b, fitted with Eq. (1).

Fig. 1 demonstrates the spirit of our approach. The cluster distributions are plotted as a function of quadrupole deformation for different cluster sizes at a fixed temperature. The yields are reproduced using a fit of the form

$$\langle n \rangle \propto q^2 \exp\left(aq^2\right). \tag{1}$$

To the extent that the quadrupole moment represents the extra surface and therefore the extra "cost" to produce a fragment, we should be able to extend the Fisher description of the cluster yields to include the effects of deformation. This analysis is currently underway.

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